

**WHAT IS CLAIMED IS:**

1. A chromatography column comprising a column having a stationary phase and a mobile phase, wherein said stationary phase comprises carbon-clad metal oxide particles having attached at least one organic group.
- 5 2. The chromatography column of claim 1, wherein said organic group comprises at least one aromatic group directly attached onto said carbon-clad metal oxide particles.
- 10 3. The chromatography column of claim 1, wherein said organic group comprises at least one alkyl group directly attached onto the carbon-clad metal oxide particles.
4. The chromatography column of claim 1, further comprising a substance comprising chemical species to be separated in said column.
- 15 5. A separation device comprising a mobile phase and a stationary phase, wherein said stationary phase comprises carbon-clad metal oxide particles having attached at least one organic group.
6. A method for conducting separation of chemical species from a substance, wherein said method comprises passing said substance through a system containing a mobile phase and a stationary phase, wherein said stationary phase comprises carbon-clad metal oxide particles having attached at least one organic group.
- 20 7. The method of claim 6, wherein said separation is liquid chromatography.
8. The method of claim 6, wherein said separation is size exclusion chromatography.
- 25 9. The method of claim 6, wherein said separation is chromatography by affinity wherein the chemical species in the substance have different affinities for the stationary phase.
10. The method of claim 6, wherein said separation is an adsorption-desorption chromatography or supercritical fluid chromatography.
11. The method of claim 6, wherein said separation is electrophoresis or electrochromatography.
- 30 12. A method for conducting separation by electrophoresis comprising a stationary phase and a mobile phase located between a positive electrode and a negative

electrode, passing a current between said electrodes, and introducing a substance containing different chemical species to be separated, wherein said stationary phase comprises carbon-clad metal oxide particles having attached at least one organic group.

13. A membrane separation system comprising a membrane wherein said membrane comprises carbon-clad metal oxide particles having attached at least one organic group.

14. The membrane separation system of claim 13, wherein said system is a reverse osmosis system.

15. An electrophoresis separation comprising a stationary phase, a mobile phase, and a positive electrode and a negative electrode, wherein said stationary phase comprises carbon-clad metal oxide particles having attached at least one organic group.

16. The separation device of claim 5, wherein the organic group is a phenyl or naphthyl group having ionic or ionizable groups.

17. The separation device of claim 5, wherein the organic group comprises an amino acid or derivatized amino acid, cyclodextrin, immobilized protein, polyproteins, or combinations thereof.

18. The separation device of claim 5, wherein the organic group comprises a  $-C_6F_5$  group, a trifluoromethyl-phenyl group, a bis-trifluorophenyl group, or combinations thereof.

19. The separation device of claim 5, wherein the organic group comprises  $-Ar-(C_nH_{2n+1})_x$  group, wherein n is an integer of from about 1 to about 30 and x is an integer of from about 1 to about 3.

20. The separation device of claim 5, wherein the organic group comprises an immobilized protein for the separations of racemic mixtures into their optically pure components.

21. The separation device of claim 5, wherein the organic group comprises polyethylene glycol or methoxy-terminated polyethyleneglycol.

22. The separation device of claim 5, wherein the organic group comprises  $-Ar-((C_nH_{2n})COOX)_m$ , wherein Ar is an aromatic group, n is 1 to 20, m is 1 to 3, and X is H, a cation, or an organic group.

23. The separation device of claim 5, wherein the organic group comprises Ar- $((C_nH_{2n})OH)_m$ , wherein Ar is an aromatic group, n is 1 to 20, m is 1 to 3.

24. The separation device of claim 5, wherein the organic group comprises -Ar- $((C_nH_{2n})NH_2)_m$ , where n is 1 to 20, m is 1 to 3, or its protonated form: -Ar- $((C_nH_{2n})NH_3X)_m$ , wherein X is an ion, and Ar is an aromatic group.

25. The separation device of claim 5, wherein the organic group comprises -Ar- $(C_nH_{2n})CHNH_3^+COO^-$  and the reaction products thereof with molecules containing functional groups terminated in -NH<sub>2</sub>, -OH, or -COOH, wherein Ar is an aromatic group.

26. The separation device of claim 19, where n=18 and x=1.

10 27. The separation device of claim 19, where n=8 and x=1.

28. The separation device of claim 26, further comprising a second organic group attached on the carbonaceous material.

29. The separation device of claim 27, further comprising a second organic group attached on the carbonaceous material.

15 30. The separation device of claim 28, where the second organic group is -Ar-C(CH<sub>3</sub>)<sub>3</sub>.

31. The separation device of claim 29, where the second organic group is -Ar-C(CH<sub>3</sub>)<sub>3</sub>

20 32. The separation device of claim 5, wherein the organic group comprises -Ar- $((C_nH_{2n})CH=CH_2)_m$ , wherein n is 0 to 20, m is 1 to 3 or -Ar- $((C_nH_{2n})SO_2CH=CH_2)_m$ , where n is 0 to 20 and m is 1 to 3.

33. The separation device of claim 5, wherein the organic group comprises at least one chiral ligand group.

25 34. The separation device of claim 16, further comprising a second organic group attached on the carbonaceous material.

35. The separation device of claim 17, further comprising a second organic group attached on the carbonaceous material.

36. The separation device of claim 18, further comprising a second organic group attached on the carbonaceous material.

30 37. The separation device of claim 19, further comprising a second organic group attached on the carbonaceous material.

38. The separation device of claim 20, further comprising a second organic group attached on the carbonaceous material.

39. The separation device of claim 21, further comprising a second organic group attached on the carbonaceous material.

5 40. The separation device of claim 22, further comprising a second organic group attached on the carbonaceous material.

41. The separation device of claim 23, further comprising a second organic group attached on the carbonaceous material.

10 42. The separation device of claim 24, further comprising a second organic group attached on the carbonaceous material.

43. The separation device of claim 25, further comprising a second organic group attached on the carbonaceous material.

44. The separation device of claim 32, further comprising a second organic group attached on the carbonaceous material.

15 45. The separation device of claim 34, wherein said second organic group has a shorter chain length or less steric hindrance than said organic group.

46. The separation device of claim 35, wherein said second organic group has a shorter chain length or less steric hindrance than said organic group.

20 47. The separation device of claim 36, wherein said second organic group has a shorter chain length or less steric hindrance than said organic group.

48. The separation device of claim 37, wherein said second organic group has a shorter chain length or less steric hindrance than said organic group.

49. The separation device of claim 38, wherein said second organic group has a shorter chain length or less steric hindrance than said organic group.

25 50. The separation device of claim 39, wherein said second organic group has a shorter chain length or less steric hindrance than said organic group.

51. The separation device of claim 40, wherein said second organic group has a shorter chain length or less steric hindrance than said organic group.

30 52. The separation device of claim 41, wherein said second organic group has a shorter chain length or less steric hindrance than said organic group.

53. The separation device of claim 42, wherein said second organic group has a shorter chain length or less steric hindrance than said organic group.

54. The separation device of claim 43, wherein said second organic group has a shorter chain length or less steric hindrance than said organic group.

55. The separation device of claim 44, wherein said second organic group has a shorter chain length or less steric hindrance than said organic group.

56. The separation device of claim 5, wherein the organic group comprises -Ar-(C<sub>n</sub>H<sub>2n</sub>)CN)<sub>m</sub>, wherein Ar is an aromatic group, n is 0 to 20, and m is 1 to 3.

57. The separation device of claim 5, wherein the organic group comprises -Ar-((C<sub>n</sub>H<sub>2n</sub>)C(O)N(H)-C<sub>x</sub>H<sub>2x+1</sub>)<sub>m</sub>, wherein Ar is an aromatic group, n is 0 to 20, x is 0 to 20 and m is 1 to 3.

58. The separation device of claim 5, wherein the organic group comprises -Ar-((C<sub>n</sub>H<sub>2n</sub>)N(H)C(O)-C<sub>x</sub>H<sub>2x+1</sub>)<sub>m</sub>, wherein Ar is an aromatic group, n is 0 to 20, x is 0 to 20 and m is 1 to 3.

59. The separation device of claim 5, wherein the organic group comprises -Ar-((C<sub>n</sub>H<sub>2n</sub>)O-C(O)-N(H)-C<sub>x</sub>H<sub>2x+1</sub>)<sub>m</sub>, wherein Ar is an aromatic group, n is 0 to 20, x is 0 to 20 and m is 1 to 3.

60. The separation device of claim 5, wherein the organic group comprises -Ar-((C<sub>n</sub>H<sub>2n</sub>)C(O)N(H)-R)<sub>m</sub>, wherein Ar is an aromatic group, n is 0 to 20, x is 0 to 20 and m is 1 to 3, and R is an organic group.

61. The separation device of claim 5, wherein the organic group comprises -Ar-((C<sub>n</sub>H<sub>2n</sub>)N(H)C(O)-R)<sub>m</sub>, wherein Ar is an aromatic group, n is 0 to 20, x is 0 to 20 and m is 1 to 3, and R is an organic group.

62. The separation device of claim 5, wherein the organic group comprises -Ar-((C<sub>n</sub>H<sub>2n</sub>)O-C(O)N(H)-R)<sub>m</sub>, wherein Ar is an aromatic group, n is 0 to 20, x is 0 to 20 and m is 1 to 3, and R is an organic group.

63. The separation device of claim 56, further comprising a second organic group attached on the carbonaceous material.

64. The separation device of claim 57, further comprising a second organic group attached on the carbonaceous material.

65. The separation device of claim 58, further comprising a second organic group attached on the carbonaceous material.

66. The separation device of claim 59, further comprising a second organic group attached on the carbonaceous material.

5 67. The separation device of claim 60, further comprising a second organic group attached on the carbonaceous material.

68. The separation device of claim 61, further comprising a second organic group attached on the carbonaceous material.

10 69. The separation device of claim 62, further comprising a second organic group attached on the carbonaceous material.

70. The separation device of claim 63, wherein said second organic group has a shorter chain length or less steric hindrance than said organic group.

71. The separation device of claim 64, wherein said second organic group has a shorter chain length or less steric hindrance than said organic group.

15 72. The separation device of claim 65, wherein said second organic group has a shorter chain length or less steric hindrance than said organic group.

73. The separation device of claim 66, wherein said second organic group has a shorter chain length or less steric hindrance than said organic group.

20 74. The separation device of claim 67, wherein said second organic group has a shorter chain length or less steric hindrance than said organic group.

75. The separation device of claim 68, wherein said second organic group has a shorter chain length or less steric hindrance than said organic group.

76. The separation device of claim 69, wherein said second organic group has a shorter chain length or less steric hindrance than said organic group.

25 77. The chromatography column of claim 1, wherein the carbon-clad metal oxide particles are carbon-clad zirconium dioxide particles.

78. The chromatography column of claim 2, wherein the carbon-clad metal oxide particles are carbon-clad zirconium dioxide particles.

30 79. The chromatography column of claim 3, wherein the carbon-clad metal oxide particles are carbon-clad zirconium dioxide particles.

80. The separation device of claim 5, wherein the carbon-clad metal oxide particles are carbon-clad zirconium dioxide particles.

81. The separation device of claim 19, wherein the carbon-clad metal oxide particles are carbon-clad zirconium dioxide particles.

5 82. The separation device of claim 5, wherein the organic group comprises an optically active aminoacid or derivatized aminoacid for the separations of racemic mixtures into their optically pure components.

10 83. The separation device of claim 5, wherein the organic group comprises cyclodextrin attached through a group -Ar(CH<sub>2</sub>)<sub>n</sub>, where n=0 to 15 for the separations of racemic mixtures into their optically pure components.